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Association of Body Mass Index and Insulin Resistance with Clinical Features in Women with Polycystic Ovary Syndrome

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ABSTRACT

Background: Polycystic ovary syndrome (PCOS) is one of the most common endocrine disorder in women of reproductive age in the world. This study was aimed to assess the relation between body mass index (BMI) and insulin resistance (IR) with clinical characteristics in PCOS diagnosed women. **Methods & Materials:** The cross-sectional study was based at Department of Gynaecology and Obstetrics, Jashore Medical College, Jashore, Bangladesh from January 2024 to December 2024. Purposive sampling was used to recruit 80 women aged 18-40 years diagnosed with PCOS based on the Rotterdam criteria. Anthropometric, fasting blood glucose, fasting insulin, and HOMA-IR were measured. The clinical features were documented in a systematic manner. Data were entered and analyzed using SPSS version 26. **Results:** The mean age of the respondents was 25.8±4.6 years. 60% of the participants had obesity (BMI ≥25 kg/m 2) and 70% had insulin resistance (HOMA-IR ≥2.5), respectively. There was an incidence of 77.5% irregular menstrual cycles, 65.0% hirsutism and 76.3% polycystic ovaries on ultrasound. Oligomenorrhea (p=0.048), hirsutism (p=0.006), acanthosis nigricans (p= 0.003), and central obesity (p<0.001) were significantly linked with higher BMI. Oligomenorrhea (p=0.021), infertility (p=0.049), hirsutism (p=0.006), acanthosis nigricans (p=0.004), and central obesity (p=0.006) were significantly related to insulin resistance. On multivariable regression, acanthosis nigricans (OR 3.54; 95% CI 1.29-9.72), hirsutism (OR 2.68; 95% CI 1.01–7.12), and BMI per unit increase (OR 1.24; 95% CI 1.08-1.43) were independent predictors of insulin resistance. **Conclusion:** There is a significant relationship between key clinical aspects of PCOS with BMI and insulin resistance. Metabolic derangements among PCOS patients should be identified early to achieve early intervention and avert cardiometabolic complications in the long-term.

Keywords: *Polycystic ovary syndrome, Body mass index, Insulin resistance, HOMA-IR, Hyperandrogenism*

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INTRODUCTION

Polycystic ovary syndrome (PCOS) is one of the most prevalent endocrine disorder amongst women of reproductive age and its worldwide prevalence is between 5% and 18% depending on the diagnostic criteria used [1]. It is a complex disorder that is defined by a threefold set of clinical findings, including hyperandrogenism, oligo-anovulation and polycystic ovarian morphology on ultrasonography as established by the Rotterdam consensus criteria [2]. In addition to its reproductive effects, PCOS is being recognized as a serious metabolic malady with far-reaching long-term health effects such as diabetic type 2 mellitus, cardiovascular disease, and endometrial carcinoma [3]. Women with PCOS have a disproportionate prevalence rate among obese and overweight people, and it has been estimated that 40 to 80% of people with the condition are overweight or obese [4]. Body mass index (BMI) has been used as a convenient surrogate measure of adiposity and has been found to have a role in worsening most of the clinical manifestation of PCOS such as menstrual irregularity, hyperandrogenic, and dysfunction of the reproductive system. Both central and visceral fat increase androgen production and aggravate the hypothalamic-pituitary-ovarian axis dysregulation, which adds to the severity of the syndrome [5]. One of the pathophysiological processes of PCOS is insulin resistance (IR), which occurs in about 50-80% of women with the condition, independent of body weight [6]. IR-induced hyperinsolinaemia increases the production of theca cell androgens, inhibits sex hormone-binding globulin (SHBG) concentration, and disfigures folliculogenesis, which leads to the continuation of clinical symptoms of PCOS. Homeostatic Model Assessment of Insulin Resistance (HOMA-IR) is a validated, economical, and frequently used method to measure insulin resistance in clinical and research practices [7]. A number of South and Southeast Asian studies have also reported the high incidence of PCOS in the Asian continent, in which women of South Asian origin can be found to have insulin resistance and metabolic complications at lower BMI than women in the West [8,9]. PCOS is an underdiagnosed but rising public health issue in Bangladesh where dietary habits, sedentary living, and poor health literacy lead to rising prevalence of metabolic disorders [10,11]. Regardless of that, there is a dearth of population-specific data that considers the interaction of BMI, insulin resistance, and the clinical phenotype of PCOS among Bangladeshi women. The relationship between BMI and IR and the variety of clinical manifestations of PCOS, including menstrual irregularities and infertility, and hyperandrogenic symptoms (hirsutism and acanthosis nigricans) are critical to the creation of specific management plans. The aim of the study was to assess the clinical, anthropometric and metabolic portfolio of women with PCOS and to assess the connections of BMI group and insulin resistance with particular clinical characteristics in a tertiary hospital in Bangladesh.

METHODS & MATERIALS

The cross-sectional study was carried out at Department of Gynaecology and Obstetrics, Jashore Medical College, Jashore, Bangladesh from January 2024 to December 2024. Purposive sampling was done and 80 women with PCOS were enrolled. The sample met the Rotterdam diagnostic criteria (2003), i.e., at least two of the following three features: oligo-anovulation, clinical or biochemical hyperandrogenism, and polycystic ovarian morphology on ultrasonography. All the participants signed the informed consent

form before enrolment. Women with thyroid disorders, hyperprolactinemia, congenital adrenal hyperplasia, Cushing syndrome, pregnancy, or known diabetes mellitus were excluded from the study. Current hormonal contraceptive users, insulin sensitizers or anti-androgens within three months of enrolment were also not included to avoid confounding of metabolic parameters. The following variables were measured: sociodemographic factors (age, residence, marital status, occupation, socioeconomic status); anthropometric variables (weight, height, BMI, waist circumference); and metabolic variables such as fasting blood glucose (mmol/L), fasting serum insulin (μIU/mL), and HOMA-IR, which was calculated as follows: [fasting insulin (The definition of insulin resistance was HOMA-IR ≥2.5. BMI was categorized as normal (18.5–22.9 kg/m²), overweight (23.0–24.9 kg/m²), and obese (≥25.0 kg/m²) per Asian-adapted cut-offs. Systematic data on clinical features such as menstrual irregularity, hirsutism, acne, alopecia, acanthosis nigricans, infertility and ultrasonographic appearance were collected. The data were inputted and analyzed in SPSS version 26.0. Means and standard deviations and frequencies with percentages were used as descriptive statistics. The chi-square test was used to determine the associations between categorical variables. Multivariate logistic regression was conducted to determine independent predictors of insulin resistance, a p-value of less than 0.05 was taken as a statistically significant value.

RESULTS

Table I shows the sociodemographic characteristic of 80 PCOS women. The majority (42.5%) were aged 23-27 years, with a mean age of 25.8 ± 4.6 years. More than half (57.5%) were urban dwellers and 52.5% were married. The majority of respondents (38.8%) were housewives, and 60% fell in the middle socioeconomic range which reflects the general demographic situation of females visiting a tertiary referral hospital in Bangladesh.

Table I
Sociodemographic Characteristics of the Study Participants (*n*=80).

Variables	Frequency (n)	Percentage (%)
Age group (years)	-	-
18-22	22	27.5
23-27	34	42.5
28-32	18	22.5
>32	6	7.5
Mean age	25.8 ± 4.6	-
Residence	-	-
Urban	46	57.5
Rural	34	42.5
Marital status	-	-
Unmarried	38	47.5
Married	42	52.5
Occupation	-	-
Student	24	30.0
Housewife	31	38.8
Service holder	17	21.3
Other	8	10.0
Socioeconomic status	-	-
Lower	19	23.8
Middle	48	60.0
Upper	13	16.3

The anthropometric and metabolic profile are summarized in *Table II*. The average body mass index was 27.6± 4.8kg/m^2 with 60% of the respondents being obese. The average HOMA-IR was 3.58±1.81 and 70% of the participants had a value of HOMA-IR above 2.5 (insulin resistance) reflecting a high metabolic burden in this cohort group.

Table II
Anthropometric and Metabolic Characteristics of the Study Participants.

Variables	Mean ± SD / Frequency (n)	Percentage (%)
Weight (kg)	67.4 ± 11.2	-
Height (m)	1.56 ± 0.07	-
BMI (kg/m²)	27.6 ± 4.8	-
Waist circumference (cm)	91.8 ± 9.7	-
Fasting blood glucose (mmol/L)	5.4 ± 0.8	-
Fasting insulin (μIU/mL)	14.9 ± 6.2	-
HOMA-IR	3.58 ± 1.81	-
BMI category	-	-
Normal (18.5-22.9)	18	22.5
Overweight (23.0-24.9)	14	17.5
Obese (≥25.0)	48	60.0
Insulin resistance status	-	-
Absent (HOMA-IR <2.5)	24	30.0
Present (HOMA-IR ≥2.5)	56	70.0

Table III describes the menstrual and reproductive features. The most common (77.5%) was irregular menstrual cycles, then oligomenorrhea (57.5%) and infertility (36.3%). 50% of the participants were nulliparous and 22.5% primary infertile. These results highlight the high reproductive morbidity of PCOS among such a population.

Table III
Menstrual and Reproductive Clinical Features of Women with PCOS.

Variables	Frequency (n)	Percentage (%)
Oligomenorrhea	46	57.5
Amenorrhea	18	22.5
Irregular menstrual cycle	62	77.5
Menorrhagia	9	11.3
Infertility	29	36.3
Primary infertility	18	22.5
Secondary infertility	11	13.8
Nulliparity	40	50.0
History of subfertility treatment	16	20.0

Table IV shows the hyperandrogenic and ultrasonographic features. The most common hyperandrogenic manifestation was hirsutism (65%), then polycystic ovaries on ultrasonography (76.3%), and finally central obesity (61.3%). Acanthosis nigricans is a cutaneous symptom of insulin resistance that was detected in 41.3% of the participants, which indicates the clinical overlap between hyperandrogenism and metabolic dysfunction.

Table IV
Hyperandrogenic and Ultrasound Features of Women with PCOS.

Variables	Frequency (n)	Percentage (%)
Hirsutism	52	65.0
Acne	37	46.3
Alopecia	19	23.8
Acanthosis nigricans	33	41.3
Polycystic ovaries on ultrasonography	61	76.3
Bilateral polycystic ovaries	44	55.0
Central obesity	49	61.3

Table V shows that oligomenorrhea (p=0.048), hirsutism (p=0.006), acanthosis nigricans (p=0.003), and central obesity (p<0.001) were significantly related to increasing BMI. The incidence of hirsutism increased to 57.1%, as compared to 38.9% in normal-BMI women. These statistically significant correlations suggest that increased adiposity worsens the hyperandrogenic as well as metabolic phenotype of PCOS.

Table V
Association of BMI Category with Clinical Features in Women with PCOS,

Clinical features	Normal BMI n=18	Overweight n=14	Obese n=48	p-value
Oligomenorrhea	7 (38.9)	7 (50.0)	32 (66.7)	0.048
Amenorrhea	2 (11.1)	3 (21.4)	13 (27.1)	0.291
Infertility	4 (22.2)	4 (28.6)	21 (43.8)	0.129
Hirsutism	7 (38.9)	8 (57.1)	37 (77.1)	0.006
Acne	10 (55.6)	7 (50.0)	20 (41.7)	0.602
Acanthosis nigricans	2 (11.1)	5 (35.7)	26 (54.2)	0.003
Central obesity	3 (16.7)	8 (57.1)	38 (79.2)	<0.001

Table VI shows that oligomenorrhea (p=0.021), infertility (p=0.049), hirsutism (p=0.006), acanthosis nigricans (p=0.004), and central obesity (p=0.006) significantly correlated with insulin resistance. Women resistant to insulin had significantly greater rates of hirsutism (75% vs 41.7%), acanthosis nigricans (51.8% vs 16.7%) than those without, emphasizing the contribution of hyperinsulinemia to the pathogenesis of both androgenic and cutaneous phenotypes.

Table VI
Association of Insulin Resistance with Clinical Features in Women with PCOS.

Clinical features	No insulin resistance (n=24)	Insulin resistance present (n=56)	p-value
Oligomenorrhea	9 (37.5)	37 (66.1)	0.021
Amenorrhea	3 (12.5)	15 (26.8)	0.164
Infertility	5 (20.8)	24 (42.9)	0.049
Hirsutism	10 (41.7)	42 (75.0)	0.006
Acne	9 (37.5)	28 (50.0)	0.311
Acanthosis nigricans	4 (16.7)	29 (51.8)	0.004
Polycystic ovaries on USG	15 (62.5)	46 (82.1)	0.071
Central obesity	9 (37.5)	40 (71.4)	0.006

Table VII presents the results of multivariable logistic regression. After adjusting for confounders, acanthosis nigricans (adjusted OR 3.54; 95% CI 1.29-9.72; p=0.014), hirsutism (adjusted OR 2.68; 95% CI 1.01–7.12; p=0.047), and BMI per unit increase (adjusted OR 1.24; 95% CI 1.08–1.43; p=0.002) emerged as independent significant predictors of insulin resistance, reinforcing the metabolic–androgenic axis in PCOS pathophysiology.

Table VII
Multivariable Logistic Regression Analysis of Factors Associated with Insulin Resistance in Women with PCOS.

Variables	Adjusted OR	95% CI	p-value
BMI (per 1 kg/m² increase)	1.24	1.08-1.43	0.002
Hirsutism	2.68	1.01-7.12	0.047
Acanthosis nigricans	3.54	1.29-9.72	0.014
Oligomenorrhea	2.31	0.91-5.86	0.078
Infertility	2.12	0.81-5.52	0.124
Age (years)	1.06	0.94-1.20	0.322

DISCUSSION

This study assessed the relationship between BMI and insulin resistance and clinical presentation of PCOS among 80 women. The most notable results were high obesity rate (60%), and insulin resistance (70%), which were significantly related to various cardinal clinical characteristics of PCOS, such as oligomenorrhea, hirsutism, acanthosis nigricans, and central obesity. Our cohort with a mean BMI of 27.6±4.8 kg/m 2 is in line with Delitala et al., who described that insulin resistance and androgen excess in PCOS are increased by obesity, which forms a vicious circle that keeps on intensifying the clinical manifestations of the disease [12]. The fact that 60% of the study population were obese is considerably greater than some study on European population, but is in line Abiri et al., where overweight and obesity are becoming more common in young women [13]. Our study has a prevalence of insulin resistance (70% using HOMA-IR 2.5 and above) that is in agreement with the general literature. Insulin resistance in PCOS is believed to be inherent and it entails defects in post-receptor signaling independent of the BMI [14]. Hyperinsulinemia increases ovarian androgen, reduces SHBG and inhibits follicular growth, so it bridges the metabolic and reproductive axes of PCOS. This mechanistic framework is supported by the fact that HOMA-IR ≥2.5 was significantly related to infertility (p=0.049) and oligomenorrhea (p=0.021), which by the work of Li et al., who showed intrinsic insulin resistance in PCOS through gold-standard clamp methods [14]. The high correlations with BMI and hirsutism (p=0.006) and acanthosis nigricans (p=0.003) in this study are in line Lizneva et al., who showed that adiposity increases androgen bioavailability [15]. The central adiposity decreases SHBG, which raises the levels of free androgen that stimulates the cutaneous hyperandrogenic phenotype including hirsutism and acne [15]. Of particular interest is the strong graded association between rising BMI and the prevalence of acanthosis nigricans (11.1% in normal BMI vs 54.2% in obese) due to the fact that this is a cutaneous manifestation that is a valid surrogate predictor of insulin resistance in clinical practice [16]. The results of the multivariate logistic regression analysis showed that acanthosis nigricans (OR 3.54), hirsutism (OR 2.68), and increased BMI (OR 1.24) were independent predictors of insulin resistance. The strongest predictor is Acanthosis nigricans: this disorder is caused by the activation of the IGF-1 receptor by overproduction of insulin in the keratinocytes and fibroblasts, and its existence has been demonstrated to be a strong predictor of insulin resistance in PCOS patients with reasonable sensitivity [16]. The independent relationship between hirsutism and IR further confirms the idea that excess androgen and insulin resistance are correlated in PCOS phenotype [17]. The nulliparity (50%) and high frequency of menstrual irregularity (77.5%) in our cohort indicates the heavy reproductive burden of PCOS among the population. These rates align with the results of the seminal PCOS systematic review study by Forslund et al., which has indicated menstrual disturbance as the most common clinical manifestation worldwide [18]. This finding that insulin resistance is significantly related to infertility (p=0.049) can be of significant clinical value since insulin-sensitising drugs like metformin have been reported to be effective in the restoration of ovulatory capacity and enhanced reproductive outcomes in women with PCOS and IR [19]. The demographic profile of this group of respondents (mainly middle socioeconomic segment, housewives, urban) represents the average tertiary hospital population in Dhaka. It is necessary to add, though, that women with lower socioeconomic status can have other barriers to healthcare access and, as a consequence, they may underrepresent the most metabolically vulnerable populations. Further community-based research using stratified sampling would be more appropriate to describe the population-wide burden of PCOS in Bangladesh. The study contributes to the growing body of evidence that PCOS among South Asian women is typified by a metabolically severe phenotype, which should be screened to insulin resistance early and subjected to specific lifestyle interventions as the foundation of the treatment [20, 21].

LIMITATIONS

The study had a small sample size (n=80) of cross-sectional design based on a single tertiary centre which could limit its ability to generalise the results to the wider Bangladeshi PCOS population. Also, no biochemical measurement of androgen levels was done, which ruled out further hormonal characterisation of subjects.

CONCLUSION

This study demonsrates that obesity and insulin resistance are very common in women with PCOS and are strongly linked with such important clinical manifestations as oligomenorrhea, hirsutism, acanthosis nigricans, and central obesity. The hyperandrogenic and metabolic phenotype of PCOS is worsened in a graded manner by increasing BMI. The connection between insulin resistance and infertility and androgenic manifestations is independent and significant, which demonstrates the primitiveness of metabolic dysfunction in the pathophysiology of PCOS. Acanthosis nigricans and hirsutism were found to be the most important independent predictors of insulin resistance, and this observation reflects the usefulness of these two composites as inexpensive clinical screening variables. These results highlight the importance of early metabolic assessment, especially BMI and HOMA-IR assessment as a standard practice of PCOS management in resource-constrained environments.

RECOMMENDATIONS

It is recommended that future longitudinal, multi-centre studies with larger, community-based samples including biochemical androgen profiling, oral glucose tolerance test, and long-term cardiometabolic outcome measures be conducted that would better characterize the

PCOS phenotype and metabolic progression in Bangladeshi women.

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CONFLICT OF INTEREST
None declared

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